Journal of Pioneering Medical Sciences
Received: January 09, 2026 | Accepted: July 16, 2026 | Published: September 05, 2026
Volume 15, Issue 08, Pages 91-99

DOI https://doi.org/10.47310/jpms2026150813

Effectiveness of Perioperative Antibiotic Prophylaxis in Preventing Surgical Site Infections in Pediatric Surgery: A Systematic Review and Meta-Analysis

Itidal Mohammed Aljohani[1*], Dareen Abdullah Alshehri[2], Reham Mohammad Aljohani[3], Almaha Hamdan Alanazi[4], Leen Mohammed Barnawi[5], Afnan Mohammed Hakami[6], Shahad Saeed Alshehri[7], Wejdan Hussain Jabri[8], Sara Mohammed Alenazi[9], Hyder Mirghani[10] and Amirah M. Alatawi[11]

[1-9]Faculty of Medicine, University of Tabuk, Tabuk, Saudi Arabia
[10]Department of Internal Medicine, Faculty of Medicine, University of Tabuk, Tabuk, Saudi Arabia
[11]Department of Family and Community Medicine, Faculty of Medicine, University of Tabuk, Tabuk, Saudi Arabia

Author Designation: [1-9]Medical Student, [10]Professor, [11]Associate Professor

*Corresponding author: Itidal Mohammed Aljohani (e-mail: eatedal1331@gmail.com).

Abstract **Background:** Surgical Site Infections (SSIs) remain an important cause of postoperative morbidity in children, resulting in prolonged hospitalization, additional interventions and increased healthcare costs. Although perioperative antibiotic prophylaxis is widely used to reduce SSI risk, recommendations differ across pediatric surgical procedures and the overall effectiveness of prophylaxis remains uncertain. **Objective:** To evaluate the effectiveness of perioperative antibiotic prophylaxis in preventing surgical site infections among pediatric surgical populations and to synthesize evidence across different prophylactic strategies. **Methods:** This systematic review and meta-analysis was conducted according to the PRISMA 2020 statement. PubMed/MEDLINE, Scopus and Web of Science were searched from database inception to December 15, 2025. Eligible studies included randomized and non-randomized comparative studies involving patients aged 0-18 years that evaluated perioperative antibiotic prophylaxis or prophylaxis strategies against no prophylaxis, standard care or an alternative antibiotic prophylaxis strategy and reported surgical site infection outcomes. Risk of bias was assessed using ROBINS-I and the certainty of evidence was evaluated using the GRADE framework. **Results:** Six studies comprising 10,351 observations and 258 SSI events were included in the quantitative synthesis. The studies evaluated different perioperative antimicrobial strategies across general pediatric, abdominal, neurosurgical, orthopedic and mixed surgical settings. Random-effects meta-analysis showed no statistically significant overall association with SSI (odds ratio 0.84, 95% confidence interval 0.66-1.08; $p = 0.19$; $I^2 = 0\%$). Despite negligible statistical heterogeneity, important clinical and methodological differences were present across the included studies. The overall certainty of evidence was rated as low. **Conclusions:** The available evidence did not demonstrate a statistically significant overall reduction in SSI associated with the perioperative antibiotic prophylaxis strategies evaluated. Because the evidence was observational and clinically heterogeneous, the pooled estimate should not be interpreted as evidence against established procedure-specific antibiotic prophylaxis recommendations. Further high-quality prospective studies are needed.

Key Words Surgical Site Infection, Antibiotic Prophylaxis, Pediatric Surgery, Perioperative Care, Antimicrobial Stewardship, Systematic Review, Meta-Analysis

INTRODUCTION

Surgical Site Infections (SSIs) remain among the most common healthcare-associated infections in pediatric surgical patients and continue to contribute substantially to postoperative morbidity, prolonged hospitalization, increased healthcare costs and impaired quality of life [1]. The incidence of SSI varies considerably according to surgical procedure, patient characteristics, wound classification and institutional practices, ranging from less than 1% in clean procedures to more than 10% in contaminated or dirty operations [2]. Despite advances in perioperative care, prevention of SSIs remains an important priority in pediatric surgery.

Perioperative antibiotic prophylaxis is an established strategy for reducing SSI risk in selected adult surgical procedures and has been widely adopted in pediatric surgical practice [3]. However, extrapolation of adult evidence to children is not always appropriate because pediatric patients

differ in immune system maturation, pharmacokinetics, pharmacodynamics, surgical indications and baseline infection risk [4]. In addition, increasing concerns regarding antimicrobial resistance, disruption of the developing microbiome, adverse drug reactions and Clostridioides difficile infection have reinforced the importance of antimicrobial stewardship and the need to avoid unnecessary antibiotic exposure in children [5].

Although perioperative antibiotic prophylaxis is widely used, important uncertainties remain regarding its effectiveness across different pediatric surgical settings. Published studies differ substantially in study design, patient populations, surgical procedures, antibiotic regimens, timing of administration, duration of prophylaxis and definitions of SSI [6]. Furthermore, baseline SSI risk differs markedly between clean procedures, contaminated abdominal operations, orthopedic trauma and neurosurgical interventions, making direct comparison between studies challenging. These differences have contributed to inconsistent findings and have limited the development of universally applicable recommendations.

Several systematic reviews have evaluated antibiotic prophylaxis in specific pediatric surgical procedures or individual surgical specialties. However, evidence remains fragmented across procedure-specific populations and no comprehensive synthesis has evaluated the overall effectiveness of perioperative antibiotic prophylaxis across the broad spectrum of pediatric surgery while simultaneously assessing the certainty of the available evidence. Although pooling clinically diverse procedures introduces important limitations, such an approach provides an overview of the current evidence base, identifies consistent patterns across studies and highlights areas where procedure-specific evidence remains insufficient. Accordingly, pooled estimates should be interpreted as providing an overall assessment of the available evidence rather than replacing procedure-specific recommendations.

Therefore, this systematic review and meta-analysis was undertaken to evaluate the effectiveness of perioperative antibiotic prophylaxis in preventing surgical site infections among pediatric patients undergoing surgical procedures. The review included comparative studies evaluating different aspects of perioperative antibiotic prophylaxis, including its use, timing, dosing, duration and adjunctive antimicrobial strategies. We hypothesized that, when considered collectively across heterogeneous pediatric surgical settings, the available evidence would not demonstrate a consistent overall reduction in SSI. We also aimed to assess the methodological quality and certainty of the available evidence, examine potential sources of heterogeneity and identify priorities for future research.

METHODS

Study Design and Reporting Standards

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [7]. The review protocol was developed prospectively with predefined eligibility criteria, study outcomes, data extraction procedures, risk-of-bias assessment and statistical methods to improve methodological transparency and reduce the risk of reporting bias. The completed PRISMA 2020 checklist is provided in Supplementary File 1.

Protocol Registration

The review protocol was developed prospectively before study selection and data extraction. Although the protocol was not registered in the International Prospective Register of Systematic Reviews (PROSPERO), all methodological decisions, including eligibility criteria, outcomes, risk-of-bias assessment and statistical analyses, were specified a priori. The absence of protocol registration is acknowledged as a limitation of this review.

Eligibility Criteria

Studies were eligible if they met the following criteria:

- **Population:** Pediatric patients aged 0-18 years undergoing any surgical procedure
- **Intervention/exposure:** Perioperative antimicrobial prophylaxis or an antimicrobial prophylaxis strategy, including administration, timing, dosing, duration, postoperative continuation or adjunctive antimicrobial measures intended to prevent postoperative infection
- **Comparator:** No prophylaxis, standard care, placebo or an alternative perioperative antimicrobial prophylaxis strategy
- **Outcome:** Surgical site infection diagnosed according to the Centers for Disease Control and Prevention (CDC) criteria or comparable validated definitions
- **Study Design:** Randomized controlled trials, prospective cohort studies, retrospective cohort studies and case-control studies

Studies involving adult populations without extractable pediatric data, case reports, case series, narrative reviews, conference abstracts, editorials, gray literature, unpublished studies and studies evaluating therapeutic rather than prophylactic antibiotic administration were excluded.

Information Sources and Search Strategy

A systematic literature search was conducted in PubMed/MEDLINE, Scopus and Web of Science from database inception through 15 December 2025. The search strategy combined Medical Subject Headings (MeSH), where applicable, with free-text terms related to pediatric surgery, perioperative antibiotic prophylaxis and Surgical Site Infection (SSI). Search terms and syntax were adapted to the requirements of each database.

To identify additional studies, the reference lists of eligible articles and relevant systematic reviews were screened manually. Forward citation tracking was performed using Google Scholar and Web of Science. The complete search strategies for all databases are available in Supplementary File 2.

Study Selection

Retrieved records were imported into Rayyan systematic review software for duplicate removal and screening [8].

Two reviewers independently screened titles and abstracts against the predefined eligibility criteria, followed by full-text assessment of potentially eligible articles. Disagreements were resolved through discussion and consensus, with consultation of a third reviewer when necessary.

Before formal screening, calibration exercises were performed to ensure consistent application of the eligibility criteria between reviewers.

Data Extraction

Two reviewers independently extracted data using a standardized, pilot-tested data extraction form. Extracted variables included study characteristics, participant demographics, surgical procedures, antibiotic regimens, comparator groups, outcome definitions, follow-up duration and effect estimates.

When multiple publications appeared to report overlapping patient populations, study characteristics, recruitment periods, participating institutions and demographic information were carefully compared. Where overlap was identified, only the most comprehensive dataset or the publication with the largest eligible population was included in the quantitative synthesis to avoid double counting.

Disagreements during data extraction were resolved through discussion or consultation with a third reviewer.

Risk-of-Bias Assessment

Risk of bias was independently assessed by two reviewers using the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) tool for observational studies [9]. For randomized controlled trials, the Cochrane Risk of Bias 2 (RoB 2) tool would have been applied [9]; however, no randomized trials met the eligibility criteria.

ROBINS-I evaluates bias across seven domains, including confounding, participant selection, intervention classification, deviations from intended interventions, missing data, outcome measurement and selective reporting. Overall risk-of-bias judgments were assigned according to ROBINS-I guidance. Disagreements were resolved by consensus or consultation with a third reviewer.

Data Synthesis and Statistical Analysis

All statistical analyses were performed using Review Manager (RevMan) version 5.4 (The Cochrane Collaboration, 2020).

The primary outcome was surgical site infection, summarized as Odds Ratios (ORs) with 95% Confidence Intervals (CIs). Owing to anticipated clinical variability across surgical procedures, patient populations, antibiotic regimens and study designs, pooled estimates were calculated using a random-effects model based on the DerSimonian and Laird method [10]. This approach was prespecified in the review protocol and selected to account for potential between-study variability. Although alternative estimators, including the Hartung-Knapp method, have been proposed for meta-analyses with a limited number of studies, the DerSimonian-Laird method was retained because it is the standard implementation within RevMan and the estimated between-study variance was negligible ($\tau^2 = 0$).

For studies reporting zero events in one treatment arm, a continuity correction of 0.5 was applied according to RevMan methodology. Studies with zero events in both groups were excluded from pooled effect estimation because they do not contribute information to relative treatment effects.

A two-sided p-value <0.05 was considered statistically significant for the primary analysis.

Assessment of Heterogeneity

Statistical heterogeneity was assessed using Cochran's Q test, the I^2 statistic and the between-study variance (τ^2) [11]. A p-value <0.10 for Cochran's Q test was considered indicative of statistically significant heterogeneity. I^2 values were interpreted according to conventional thresholds: 0-25% (low), 26-50% (moderate), 51-75% (substantial) and >75% (considerable heterogeneity) [11].

Subgroup and Sensitivity Analyses

Prespecified subgroup analyses were planned according to surgical category, wound classification, timing of antibiotic prophylaxis, patient age and study design. However, the small number of studies within individual categories limited meaningful subgroup comparisons; therefore, these analyses were considered exploratory and were undertaken only where sufficient data were available.

Sensitivity analyses were planned to assess the robustness of the pooled estimate by considering the influence of studies with higher risk of bias, differences in SSI definitions and shorter follow-up periods. A sensitivity analysis excluding the study judged to have a serious overall risk of bias was also prespecified where feasible. Because of the small number of included studies and differences in surgical procedures, antimicrobial strategies and units of analysis, all sensitivity analyses were interpreted cautiously.

Publication Bias

Publication bias was assessed by visual inspection of funnel plot symmetry. Formal statistical testing using Egger's regression was not performed because fewer than ten studies were included, consistent with recommendations in the Cochrane Handbook for Systematic Reviews of Interventions [12].

Certainty of Evidence

The certainty of evidence for the primary outcome was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework [13]. Evidence was assessed across five domains: risk of bias, inconsistency, indirectness, imprecision and publication bias. The overall certainty of evidence was categorized as high, moderate, low or very low according to established GRADE guidance.

RESULTS

Study Selection

The database search identified 232 records: 98 from PubMed/MEDLINE, 87 from Scopus and 47 from Web of Science. After removal of 43 duplicates, 189 records underwent title and abstract screening, of which 146 were excluded. The full texts of 43 reports were assessed for eligibility. Following full-text assessment, 37 reports were excluded, leaving six studies that met the eligibility criteria and were included in both the systematic review and quantitative synthesis. The study selection process is presented in the PRISMA 2020 flow diagram (Figure 1).

PRISMA 2020 flow diagram illustrating the identification, screening, eligibility assessment and inclusion of studies in the systematic review and meta-analysis (Figure 1). Records were identified through searches of PubMed/MEDLINE, Scopus and Web of Science. After duplicate removal and eligibility assessment, six studies met the inclusion criteria and were included in both the qualitative synthesis and quantitative meta-analysis.

Study Characteristics

The six included studies comprised retrospective cohort and database-based observational studies conducted in Japan and the United States. The studies covered a broad range of pediatric surgical settings, including clean general pediatric surgery, abdominal surgery, open lower-extremity fractures, cerebrospinal fluid shunt surgery, mixed pediatric surgical procedures and nonperforated appendicitis. The exposure comparisons also varied and included antibiotic use versus no prophylaxis, shorter versus longer prophylaxis duration, early versus delayed administration, adjunctive infection-prevention strategies, adherence to prophylactic dosing recommendations and postoperative antibiotics versus no postoperative antibiotics. Detailed study characteristics are presented in Table 1.

For Fujii *et al.* [6], the comparative analysis was conducted at the wound level. The study included 926 patients with 1,389 surgical wounds; 492 wounds received preoperative antibiotics and 897 did not.

Risk-of-Bias Assessment

Risk of bias was assessed using the ROBINS-I tool. Five of the six included studies were judged to have an overall moderate risk of bias, while one study was judged to have a serious risk of bias. The principal concern across the studies was residual confounding related to their observational designs. Jacobo *et al.* [1] was judged to have a serious risk of bias because several clinically important determinants of surgical site infection, including Gustilo fracture classification and operative characteristics, were unavailable for adjustment. Classification of interventions and selection of reported results were generally judged to be at low risk. Domain-specific assessments are presented in Table 2.

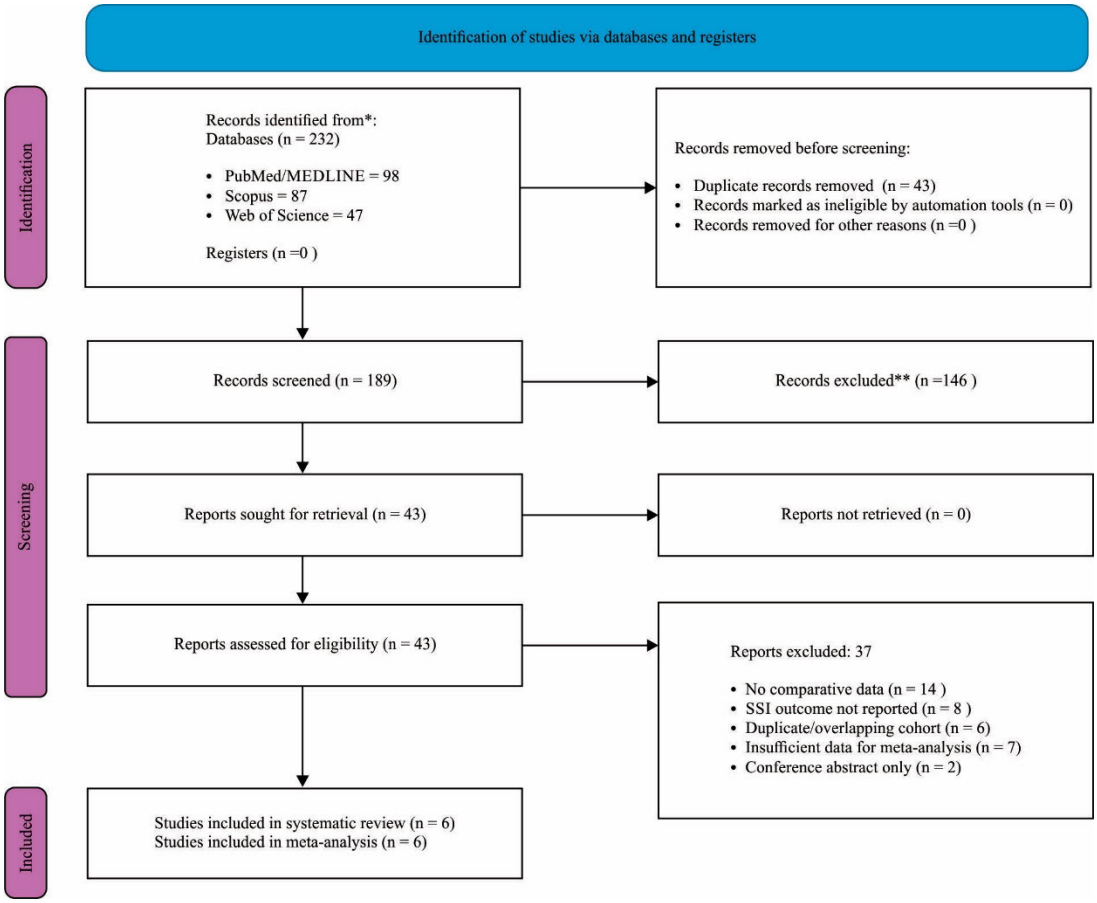

Figure 1: PRISMA 2020 Flow Diagram for New Systematic Reviews

Table 1: Characteristics of Included Studies

Study	Country	Design	Surgical procedure	Sample size/unit	Intervention	Comparator	Follow-up	SSI definition
Fujii *et al.* [6]	Japan	Retrospective cohort	UDT, open inguinal hernia repair, LPEC and umbilical hernia repair	492/897 wounds	Preoperative antibiotics, predominantly cefazolin	No preoperative antibiotics	30 days	CDC-based clinical definition
Takayasu *et al.* [5]	Japan	Retrospective cohort	Pediatric abdominal surgery: intestinal atresia, hepaticojejunostomy and stoma closure	39/54 patients	PAMP completed within 24 h	PAMP continued beyond 24 h	30 days	CDC superficial incisional SSI criteria
Jacobo *et al.* [1]	USA	Retrospective TQIP database cohort	Operatively treated open femur/tibia fractures	98/52 patients	Antibiotics within 1 h of arrival	Antibiotics ≥1 h after arrival	Not clearly specified as a fixed surveillance interval in the article	SSI including superficial, deep and osteomyelitis
Podkovik *et al.* [3]	USA	Multicenter retrospective cohort	Initial and revision CSF shunt surgery	1,297 standard/964 IT antibiotics/695 AIC/138 both; 3,094 procedures	Intrathecal antibiotics and/or antibiotic-impregnated catheter	Standard IV prophylaxis with conventional catheter	6 months	HCRN consensus definition, not CDC
Berrondo *et al.* [2]	USA	Retrospective NSQIP-Pediatric database cohort	Mixed pediatric surgical procedures	2,093/3,961 surgeries†	Correct weight-based prophylactic antibiotic dosing	Non-adherent weight-based dosing	30 days	NSQIP-Pediatric SSI definition
Cramm *et al.* [14]	USA	Multicenter retrospective cohort	Nonperforated appendicitis with gangrenous, suppurative or exudative findings	202/202 patients‡	Postoperative antibiotics	No postoperative antibiotics	30 days	NSQIP-Pediatric SSI outcome: incisional and organ-space infection

AIC: Antibiotic-impregnated catheter, CDC: Centers for Disease Control and Prevention, CSF: Cerebrospinal fluid, HCRN: Hydrocephalus Clinical Research Network, IT: Intrathecal, LPEC: Laparoscopic percutaneous extraperitoneal closure, NSQIP-Pediatric: National Surgical Quality Improvement Program-Pediatric, PAMP: Perioperative antimicrobial prophylaxis, SSI: Surgical site infection, TQIP: Trauma Quality Improvement Program, UDT: Undescended testis, †: For Berrondo *et al.* [2], the study included 6,072 surgical procedures among 5,532 patients overall, The 2,093/3,961 denominators shown in the table correspond specifically to the analysis of adherence versus non-adherence to weight-based antibiotic dosing; the surgical procedure was the unit of analysis, ‡: For Cramm *et al.* [14], 958 children were included in the overall cohort; the comparative patient-level propensity-matched analysis included 404 children, with 202 patients in each group

Table 2: Risk of Bias Assessment of Included Studies Using the ROBINS-I Tool

Study	Confounding	Selection of Participants	Classification of Intervention	Deviations from Intended Intervention	Missing Data	Outcome Measurement	Selection of Reported Results	Overall Risk
Fujii *et al.* [6]	Moderate	Moderate	Low	Low	Low	Moderate	Low	Moderate
Takayasu *et al.* [5]	Moderate	Moderate	Low	Low	Low	Low	Low	Moderate
Jacobo *et al.* [1]	Serious	Moderate	Low	Low	Moderate	Low	Low	Serious
Podkovik *et al.* [3]	Moderate	Low	Low	Low	Low	Low	Low	Moderate
Berrondo *et al.* [2]	Moderate	Moderate	Low	Low	Low	Low	Low	Moderate
Cramm *et al.* [14]	Moderate	Moderate	Low	Low	Low	Low	Low	Moderate

ROBINS-I domains: Bias due to confounding, bias in selection of participants into the study, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in measurement of outcomes and bias in selection of the reported result [9]

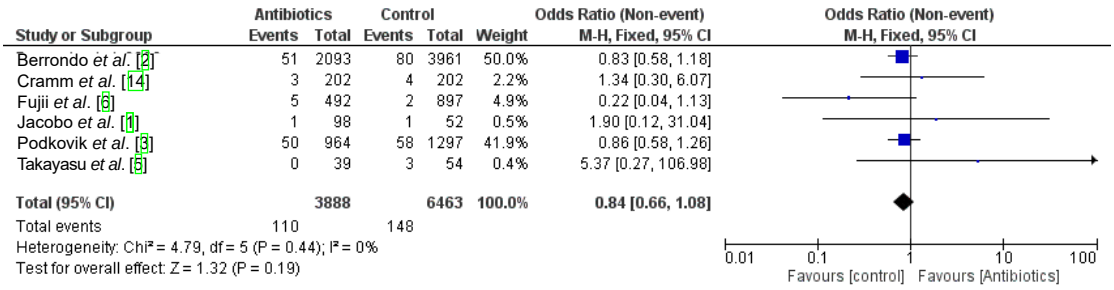

Figure 2: Forest Plot of Perioperative Antibiotic Prophylaxis Strategies and Surgical Site Infection in Pediatric Surgery

Primary Outcome: Surgical Site Infection

All six included studies reported Surgical Site Infection (SSI) outcomes. A total of 10,351 observations and 258 SSI events contributed to the quantitative synthesis. Because the included studies used different units of analysis, including patients, surgical procedures and surgical wounds, the aggregate sample is reported as observations rather than unique patients.

Pooled analysis using a random-effects model showed no statistically significant overall association between the antimicrobial prophylaxis strategies evaluated and SSI (OR 0.84, 95% CI 0.66-1.08; p = 0.19; Z = 1.32) (Figure 2). The point estimate favored the intervention; however, the confidence interval crossed the line of no effect, indicating that the pooled result was not statistically significant.

Individual study estimates varied in precision across the different surgical settings and antimicrobial strategies. Several studies had few infection events and consequently wide confidence intervals. The pooled estimate should therefore be interpreted in the context of the clinical and methodological diversity of the included studies.

Six studies comprising 10,351 observations and 258 SSI events contributed to the quantitative synthesis. The pooled random-effects estimate showed no statistically significant overall association with SSI (OR 0.84, 95% CI 0.66-1.08; p = 0.19; Z = 1.32). Statistical heterogeneity was negligible ($I^2 = 0\%$; $\tau^2 = 0.00$; $\chi^2 = 4.79$, df = 5; p = 0.44).

Assessment of Statistical Heterogeneity

No statistically significant heterogeneity was detected among the included studies. Cochran's Q test was not significant ($\chi^2 = 4.79$, df = 5, p = 0.44), the estimated between-study variance was negligible ($\tau^2 = 0.00$) and the I^2 statistic was 0%.

Despite the absence of measurable statistical heterogeneity, important clinical heterogeneity remained. The included studies differed in surgical procedures, antimicrobial strategies, comparator definitions, follow-up periods and units of analysis. The low I^2 should therefore not be interpreted as evidence of clinical homogeneity.

Subgroup Analyses

Prespecified subgroup analyses were planned according to surgical category and study design when sufficient studies were available. However, after restriction to the six studies included in the final quantitative synthesis, the number of studies within comparable surgical categories was too small to support reliable pooled subgroup analyses.

Furthermore, all six studies included in the final review used retrospective observational designs. Consequently, a meaningful comparison between prospective and retrospective studies could not be performed. Differences according to surgical setting and antimicrobial strategy were therefore considered descriptively and should be interpreted as exploratory.

Sensitivity Analyses

Sensitivity analysis was performed by excluding Jacobo *et al.* [1], the only study judged to have a serious overall risk of bias. Exclusion of this study did not materially change the pooled estimate (random-effects OR 0.84, 95% CI 0.63-1.12; p = 0.17) and statistical heterogeneity remained low ($I^2 = 8\%$). Given the small number of studies and the substantial variation in surgical setting, intervention definition and unit of analysis, additional sensitivity analyses were not considered sufficiently informative and were therefore not pursued.

Publication Bias

Assessment of publication bias was limited by the inclusion of only six studies. Formal statistical testing for funnel plot asymmetry, including Egger's regression test, was not performed because fewer than ten studies contributed to the meta-analysis.

Visual inspection of the funnel plot did not show marked asymmetry (Figure 3). However, given the small number of included studies, the ability of the funnel plot to detect small-study effects or publication bias was limited. Therefore, publication bias cannot be excluded.

Funnel plot of the six comparative studies included in the meta-analysis of perioperative antibiotic prophylaxis and Surgical Site Infection (SSI) in pediatric surgery. Each point represents an individual study plotted according to its log odds ratio and corresponding standard error. The vertical dashed line represents the pooled effect estimate (OR = 0.84). Visual inspection did not show marked asymmetry; however, given the small number of included studies, the funnel plot has limited ability to detect small-study effects or publication bias. Formal statistical testing for funnel plot asymmetry, including Egger's regression test, was not performed because fewer than ten studies were available.

Table 3: The Certainty of Evidence for the Primary Outcome

Outcome	No. of Studies	Observations	Events	Relative Effect (95% CI)	Certainty of Evidence
Surgical site infection	6	10,351	258	OR 0.84 (95% CI 0.66-1.08)	⊕⊕◯◯ Low

Footnote: The included studies used different units of analysis, including individual patients, surgical procedures and surgical wounds. The total of 10,351 therefore represents observations contributing to the quantitative synthesis and should not be interpreted as 10,351 unique pediatric patients

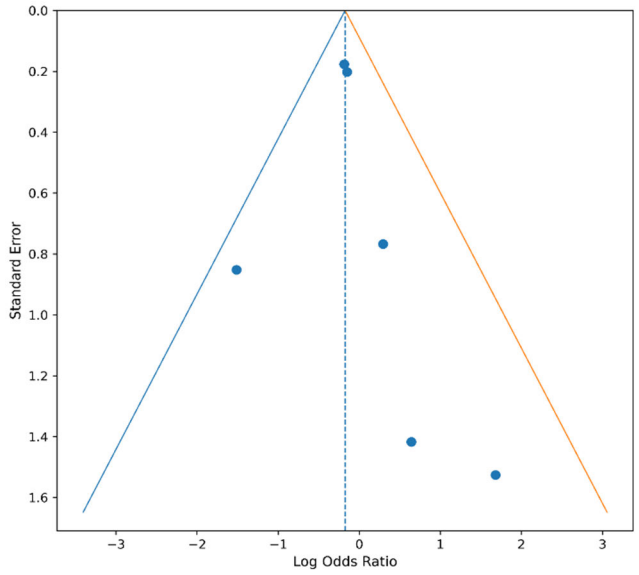

Figure 3: Funnel Plot for Assessment of Potential Publication Bias

Certainty of Evidence (GRADE Assessment)

The certainty of evidence for the primary outcome was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach and was rated as low (Table 3).

Because the body of evidence consisted entirely of non-randomized observational studies, the starting certainty was low. Risk of bias and indirectness were considered important limitations because of residual confounding, selection bias, differences in surgical procedures, antimicrobial strategies, comparator definitions, clinical settings and units of analysis.

The evidence was not downgraded for inconsistency because statistical heterogeneity was negligible ($I^2 = 0\%$). Imprecision was considered carefully because the 95% confidence interval crossed the line of no effect. No additional downgrade for imprecision was applied because the confidence interval was relatively narrow around the pooled estimate and did not indicate a large increase in SSI risk, although a clinically meaningful benefit could not be excluded. Publication bias could not be formally assessed because only six studies were available and visual inspection of the funnel plot should therefore be interpreted cautiously. Overall, the certainty of evidence for the primary outcome was judged to be low.

DISCUSSION

Principal Findings

This systematic review and meta-analysis included six studies evaluating different aspects of perioperative antibiotic prophylaxis across a range of pediatric surgical settings. The pooled analysis did not show a statistically significant overall reduction in Surgical Site Infection (SSI) (OR 0.84, 95% CI 0.66-1.08). Although the point estimate favored the intervention, the confidence interval included the line of no effect. The findings therefore do not establish an overall reduction in SSI across the surgical populations represented in this review.

The result should not be interpreted as evidence that perioperative antibiotic prophylaxis is ineffective. The included studies addressed different aspects of antimicrobial practice, including administration versus no administration, duration of prophylaxis, timing of antibiotic administration, adherence to recommended dosing, adjunctive infection-prevention strategies and postoperative antibiotic use. The pooled estimate consequently represents an overall synthesis of these different strategies rather than a direct comparison of a single prophylactic regimen with no prophylaxis.

The certainty of evidence was rated as low using the GRADE approach. This reflected the observational nature of the evidence, residual risk of confounding and indirectness arising from differences in surgical procedures, antimicrobial strategies, comparators and units of analysis [11]. These limitations are important when considering the clinical meaning of the pooled estimate.

Comparison with Previous Literature

The findings are consistent with the broader pediatric surgical literature showing that the role of antimicrobial prophylaxis depends on the procedure, baseline infection risk and circumstances of antibiotic administration. Fujii *et al.* [6], for example, examined preoperative antibiotic use in common pediatric surgical procedures with relatively low infection rates, whereas Takayasu *et al.* [5] focused on whether prophylaxis needed to continue beyond 24 hours after pediatric abdominal surgery. Cramm *et al.* [14] similarly examined the value of postoperative antibiotics in children with nonperforated appendicitis with gangrenous, suppurative or exudative findings.

Other included studies addressed different questions. Jacobo *et al.* [1] evaluated the timing of antibiotic administration in children with open lower-extremity fractures, Berrondo *et al.* [2] examined adherence to perioperative prophylaxis recommendations in a large pediatric surgical cohort and Podkovik *et al.* [3] evaluated infection-prevention strategies in cerebrospinal fluid shunt surgery. Taken together, these studies illustrate why the effectiveness of perioperative antimicrobial strategies cannot be separated from the procedure, indication, timing, duration and method of administration.

Unlike reviews confined to a single surgical procedure, the present review examined evidence across different areas of pediatric surgery. This provides a broader picture of the available evidence but also limits the clinical specificity of

the pooled estimate. The overall effect should therefore be viewed as a summary of the available literature rather than evidence for a uniform antimicrobial strategy across pediatric surgery.

Clinical Heterogeneity

Clinical heterogeneity was an important feature of the evidence. The included studies covered general pediatric surgery, abdominal surgery, open orthopedic trauma, cerebrospinal fluid shunt surgery, mixed pediatric surgical procedures and nonperforated appendicitis. These procedures differ considerably in baseline infection risk, degree of contamination, use of implanted material, patient characteristics and indications for antimicrobial therapy.

The studies also differed in what constituted the intervention and comparator. Some examined whether antibiotics were administered, whereas others examined timing, duration, dosing adherence, postoperative continuation or adjunctive antimicrobial strategies. In addition, the unit of analysis was not uniform across studies and included patients, surgical procedures and surgical wounds.

Statistical heterogeneity was negligible ($I^2 = 0\%$), but this does not remove these clinical differences. An I^2 of 0% indicates that measurable variation in the study effect estimates was not greater than expected from sampling variability; it does not establish that the studies were clinically equivalent. The pooled result should therefore be interpreted alongside the substantial differences in populations, procedures and antimicrobial approaches.

Implications for Antimicrobial Stewardship

The findings are relevant to antimicrobial stewardship in pediatric surgery. Antibiotic prophylaxis remains an important component of SSI prevention when supported by the type of procedure and expected infection risk. At the same time, unnecessary administration or continuation of antibiotics exposes children to treatment without established additional benefit and may contribute to adverse drug effects, antimicrobial resistance, increased resource use and disruption of the microbiome.

The lack of a statistically significant overall association in this review should therefore not be used to support withholding prophylaxis where its use is recommended. Rather, the findings reinforce the importance of tailoring antimicrobial practice to the surgical procedure and clinical circumstances. Decisions regarding antibiotic selection, timing and duration should remain guided by procedure-specific evidence and established recommendations rather than by the pooled estimate from this review.

Strengths and Limitations

This review has several strengths. It was conducted and reported in accordance with PRISMA 2020 [7], used a systematic search of multiple electronic databases, assessed risk of bias using ROBINS-I [9] and evaluated certainty of evidence using the GRADE framework [13]. The review also included studies from different pediatric surgical settings, providing an overview of antimicrobial practices across a broad clinical spectrum.

Several limitations should be considered. First, although the review protocol was developed prospectively, it was not registered in PROSPERO. Second, all six included studies were retrospective observational studies, leaving the findings susceptible to residual confounding and selection bias. Third, the studies differed substantially in surgical procedures, antimicrobial strategies, comparator definitions, follow-up periods and units of analysis. These differences limit the clinical interpretation of a single pooled estimate despite the absence of measurable statistical heterogeneity.

Fourth, only six studies were available for quantitative synthesis, which limited meaningful subgroup analyses and reduced the precision of sensitivity analyses. Fifth, the search was limited to PubMed/MEDLINE, Scopus and Web of Science and did not include Embase or CENTRAL; restriction to English-language published studies and the exclusion of gray literature may also have introduced language and publication bias. The small number of studies precluded formal statistical testing for funnel plot asymmetry and publication bias cannot be excluded. Finally, because some studies analyzed surgical procedures or wounds rather than individual patients, the overall number of observations should not be interpreted as the number of unique children represented in the meta-analysis.

Future Research

Further research should focus on clearly defined pediatric surgical populations rather than combining substantially different procedures. Prospective multicenter studies and, where feasible, randomized controlled trials are needed to determine which procedures benefit from prophylaxis and to establish the appropriate antibiotic, timing and duration.

Future studies should use standardized SSI definitions and clearly distinguish prophylactic treatment from postoperative therapeutic antibiotic use. Outcomes should extend beyond SSI to include adverse drug events, antimicrobial resistance, length of stay, resource use and other consequences of unnecessary antibiotic exposure. Larger procedure-specific evidence bases would also permit more reliable meta-analyses and clinically useful recommendations.

CONCLUSIONS

The available evidence did not demonstrate a statistically significant overall reduction in SSI associated with the perioperative antibiotic prophylaxis strategies evaluated. However, the evidence was of low certainty and was derived from six retrospective observational studies that differed considerably in surgical procedures, prophylactic strategies, comparators and units of analysis.

These findings should not be interpreted as evidence against established antibiotic prophylaxis. Rather, they highlight the limitations of applying a single pooled estimate across clinically different pediatric surgical settings and

support procedure-specific approaches to antibiotic selection, timing, dosing and duration. Perioperative antibiotic use should continue to follow procedure-specific evidence and established clinical recommendations. Further prospective studies are needed to define the most appropriate indications, timing, dosing and duration of antibiotic prophylaxis for individual pediatric surgical procedures.

REFERENCES

[1] Jacobo, M. *et al.* "Antibiotics within One Hour for Pediatric Open Lower Extremity Fractures May Not Be Warranted as a Quality Metric." *The American Surgeon*, vol. 91, no. 1, 2025, pp. 59-64. https://doi.org/10.1177/00031348241269392.

[2] Berrondo, C. *et al.* "Adherence to Perioperative Antibiotic Prophylaxis Recommendations and Its Impact on Postoperative Surgical Site Infections." *Cureus*, vol. 14, no. 6, 2022. https://doi.org/10.7759/cureus.25859.

[3] Podkovik, S. *et al.* "Antibiotic Impregnated Catheters and Intrathecal Antibiotics for CSF Shunt Infection Prevention in Children Undergoing Low-Risk CSF Shunt Surgery." *BMC Pediatrics*, vol. 24, 2024. https://doi.org/10.1186/s12887-024-04798-9.

[4] Bedir Demirdag, T. *et al.* "Antimicrobial Surgical Prophylaxis: Still an Issue in Paediatrics." *Journal of Global Antimicrobial Resistance*, vol. 23, 2020, pp. 224-227. https://doi.org/10.1016/j.jgar.2020.09.020.

[5] Takayasu, H. *et al.* "Postoperative Continuation of Antibiotic Prophylaxis beyond 24 h Is Unnecessary for Abdominal Surgeries in Children and Neonates." *Journal of Pediatric Surgery Open*, vol. 8, 2024. https://doi.org/10.1016/j.yjpso.2024.100179.

[6] Fujii, T. *et al.* "Do We Need Preoperative Antibiotics in Common General Pediatric Surgery Procedures?" *Cureus*, vol. 16, no. 7, 2024. https://doi.org/10.7759/cureus.65805.

[7] Page, M.J. *et al.* "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews." *BMJ*, vol. 372, 2021. https://doi.org/10.1136/bmj.n71.

[8] Ouzzani, M. *et al.* "Rayyan-A Web and Mobile App for Systematic Reviews." *Systematic Reviews*, vol. 5, 2016. https://doi.org/10.1186/s13643-016-0384-4.

[9] Sterne, J.A.C. *et al.* "ROBINS-I: A Tool for Assessing Risk of Bias in Non-Randomised Studies of Interventions." *BMJ*, vol. 355, 2016. https://doi.org/10.1136/bmj.i4919.

[10] DerSimonian, R. and N. Laird. "Meta-Analysis in Clinical Trials." *Controlled Clinical Trials*, vol. 7, no. 3, 1986, pp. 177-188. https://doi.org/10.1016/0197-2456(86)90046-2.

[11] Higgins, J.P.T. *et al.* "Measuring Inconsistency in Meta-Analyses." *BMJ*, vol. 327, no. 7414, 2003, pp. 557-560. https://doi.org/10.1136/bmj.327.7414.557.

[12] Higgins, J.P.T. *et al.* "Cochrane Handbook for Systematic Reviews of Interventions." *Cochrane*, version 6.5, 2024. https://www.training.cochrane.org/handbook.

[13] Guyatt, G.H. *et al.* "GRADE Guidelines: 1. Introduction-GRADE Evidence Profiles and Summary of Findings Tables." *Journal of Clinical Epidemiology*, vol. 64, no. 4, 2011, pp. 383-394. https://doi.org/10.1016/j.jclinepi.2010.04.026.

[14] Cramm, S.L. *et al.* "Postoperative Antibiotics, Outcomes and Resource Use in Children with Gangrenous Appendicitis." *JAMA Surgery*, vol. 159, no. 5, 2024, pp. 511-517. https://doi.org/10.1001/jamasurg.2023.7754.